Correlated Background for Quarkonia in SPHENIX

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What's new

Completely new simulation with PYTHIA 6 tuning from ppg189
(e+e- pairs from open heavy flavor in p+p and d+Au at mid-rapidity, arXiv:1702.01084 , submitted to PRC)

Use new results on charm and bottom suppression and bottom fraction.

Much more statistics, no need to scale up the simulation, easy p_T binning.

Simulation details

New PYTHIA6 tuning (ppg189)

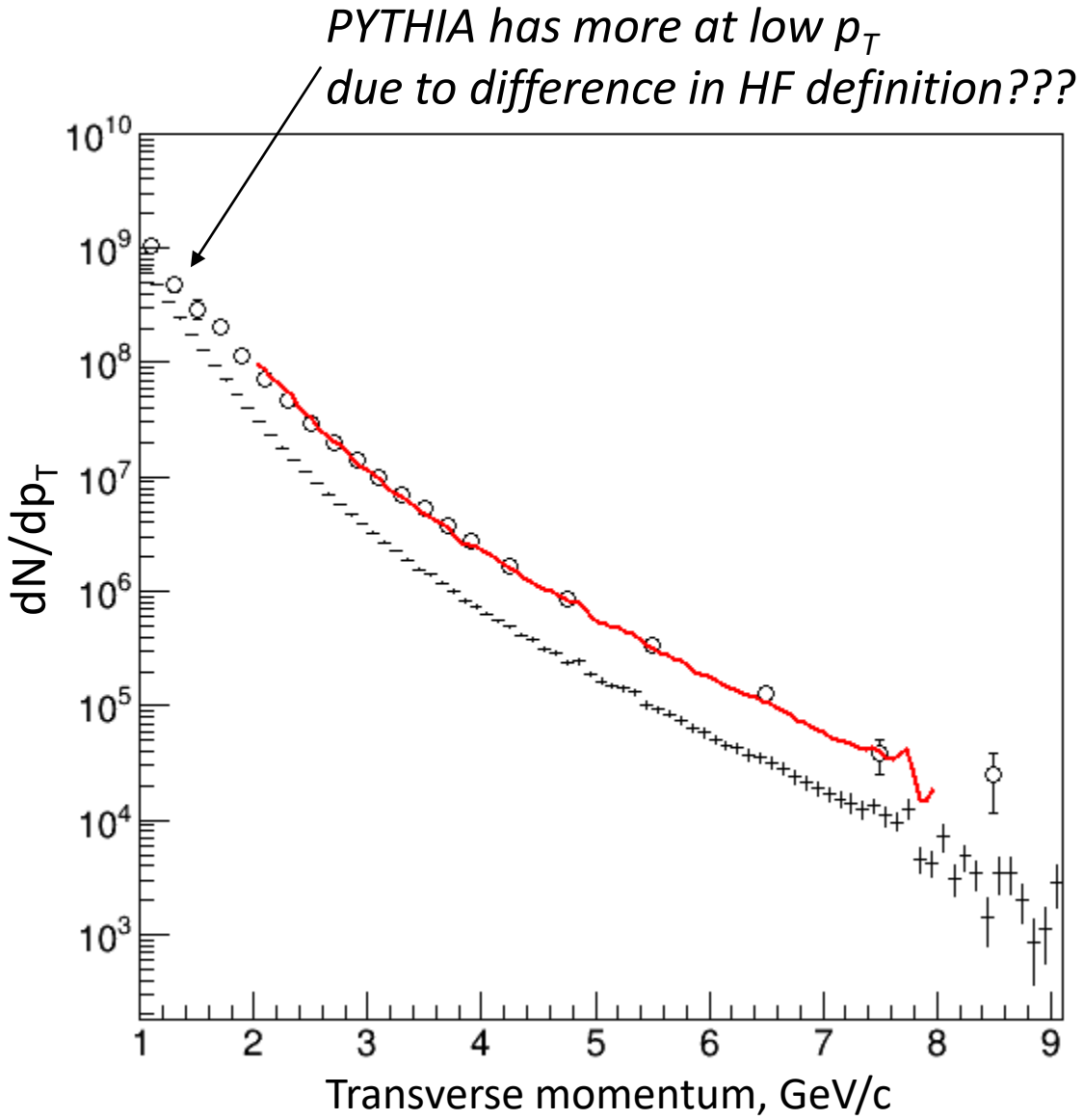
For the background calculation I use $PHPy6ForwardElectronTrig$ trigger requiring at least one e+ AND one e- in acceptance.

For cross-check and comparison to the data I also run with trigger requiring only one electron in acceptance.

Correlated charm requires the longest CPU time.
For charm I produce two sets, one with ckin(3)=4 to save CPU time, and one without it.
Right now I have enough statistics for ckin(3)=4.

If you believe PYTHIA cross-section, then:
Generate 10B * 955 PYTHIA p+p collisions and apply suppression from the data to imitate 10B 0-10% central Au+Au events.
Cross-section scaling is necessary.

p+p cross-check for Heavy Flavor single electrons



Open circles: PHENIX p+p data from ppg066 (run5)
Scaled to 9550B Min.Bias p+p collisions.

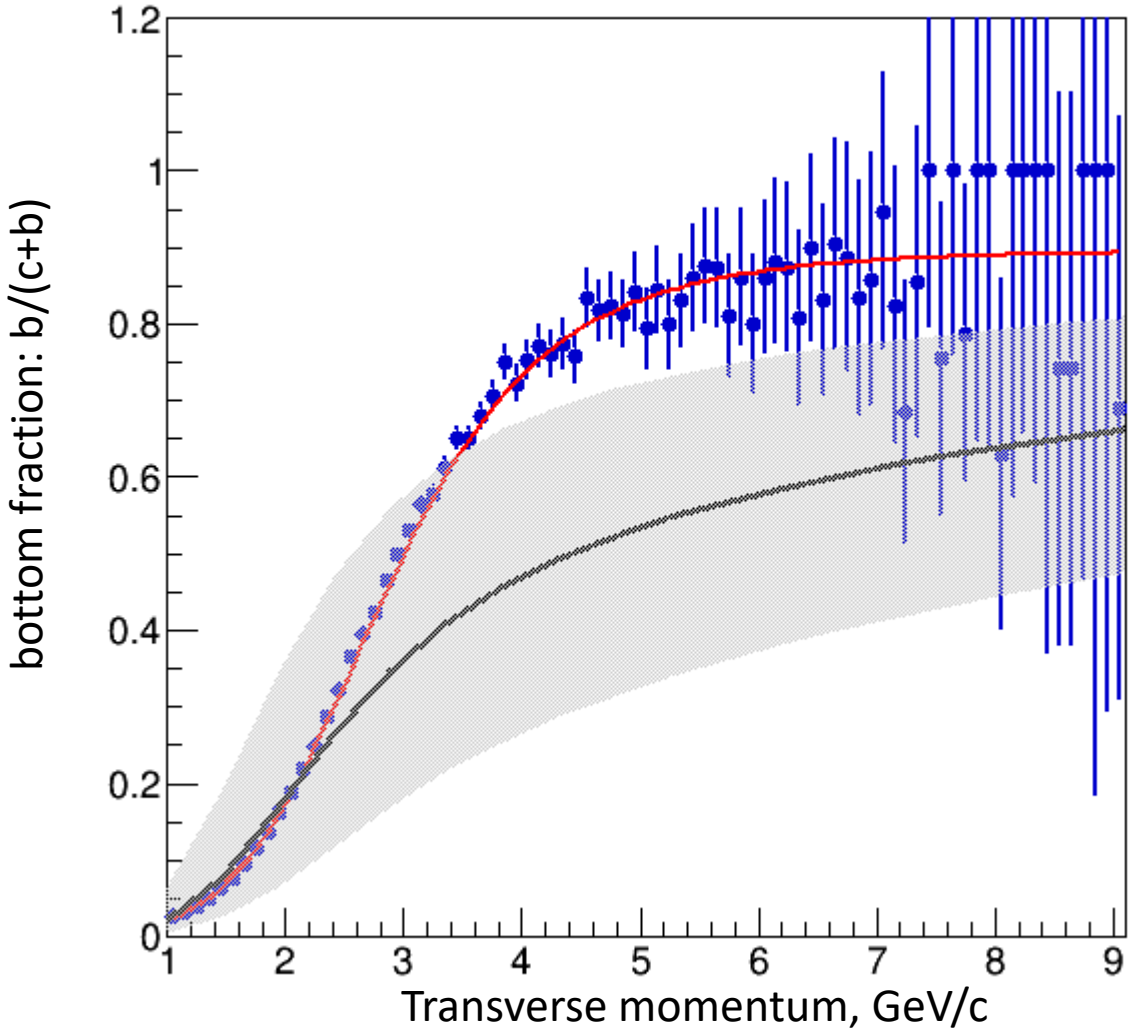
Crosses: PYTHIA corresponding to 9550B Min.Bias collisions

Red curve: fit of PYTHIA to the data

Good agreement in shape, but PYTHIA cross-section is 3.27 ± 0.04 times lower than the data (see backup slide).

What about charm and bottom separately?

charm/bottom separation for the data

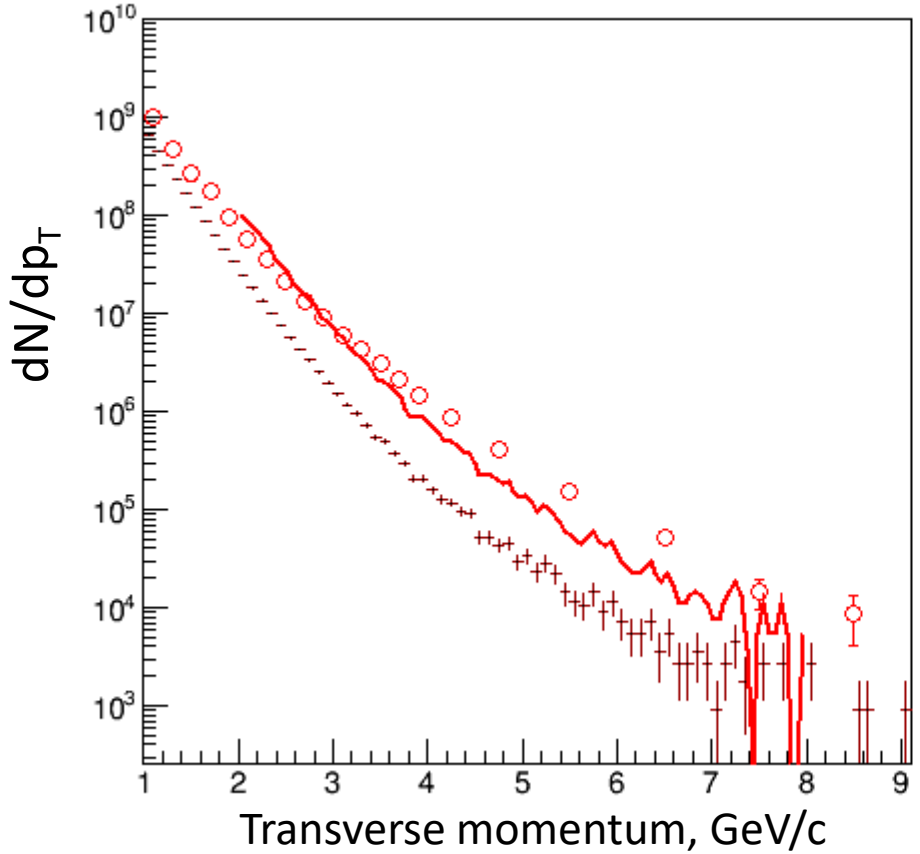


Black: FONLL
Blue: PYTHIA

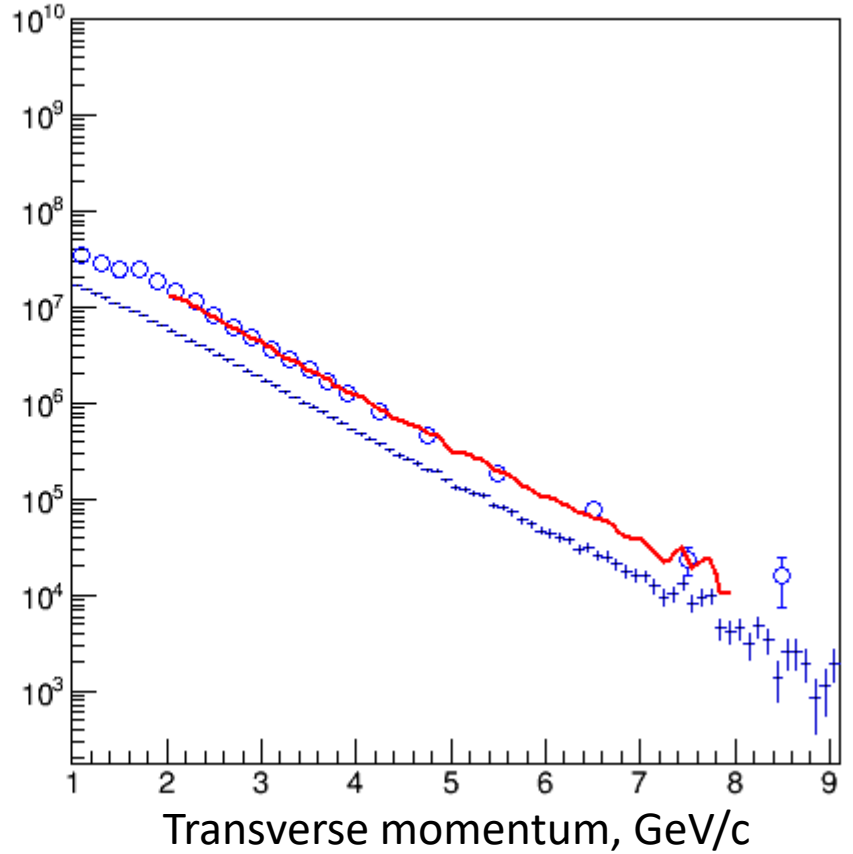
Use these functions to split data into charm and bottom.

p+p charm and bottom: FONLL bottom fraction

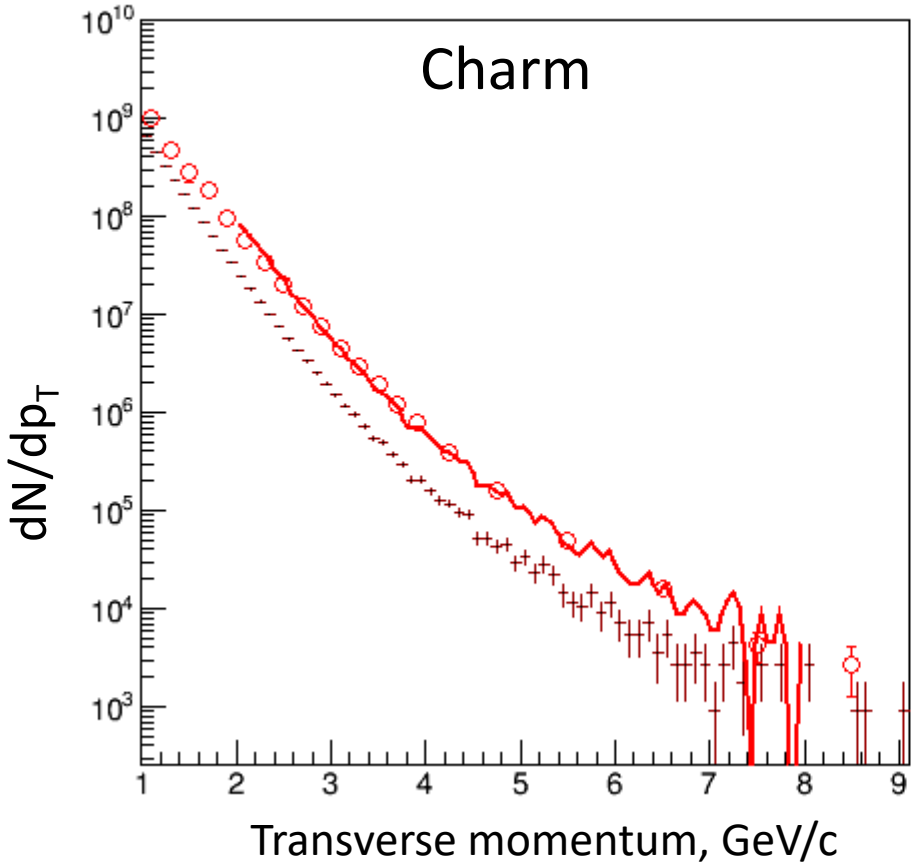
Charm

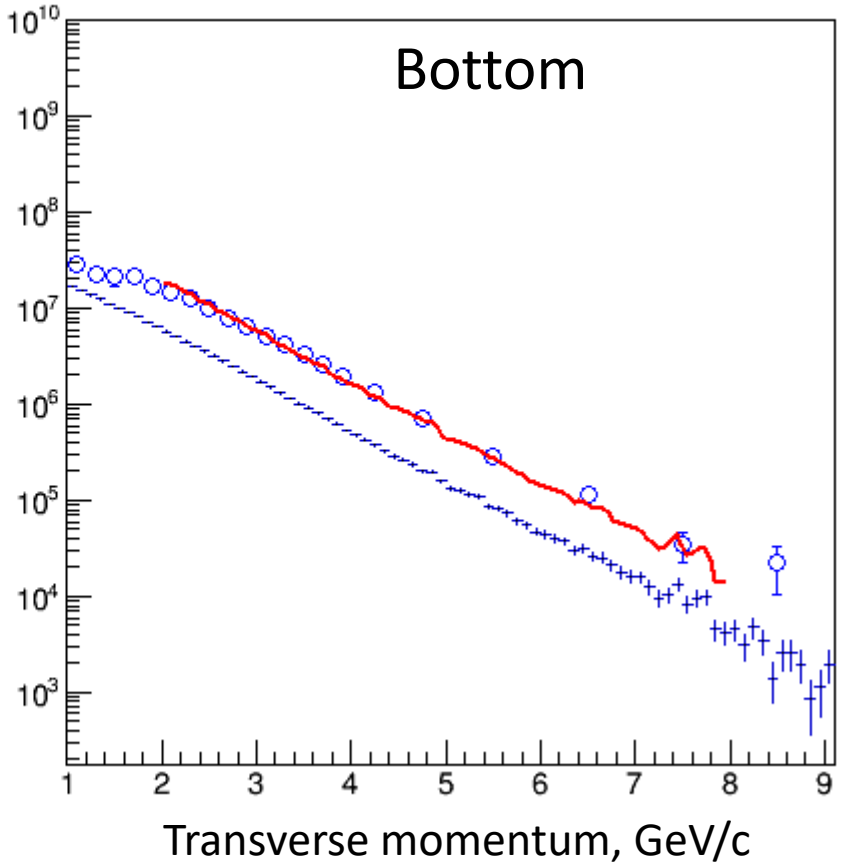


Bottom



p+p charm and bottom: PYTHIA bottom fraction





charm normalization = 3.32 +- 0.04 (fit above 3 GeV: 3.58 +- 0.06

bottom normalization = 3.22 +- 0.04 (fit above 3 GeV: 3.43 +- 0.06

HF normalization = 3.27 +- 0.04 (fit above 3 GeV: 3.50 +- 0.06

Some intermediate conclusions

I think we can say that PYTHIA is in good agreement with the p+p data except that it needs cross-section scaling.

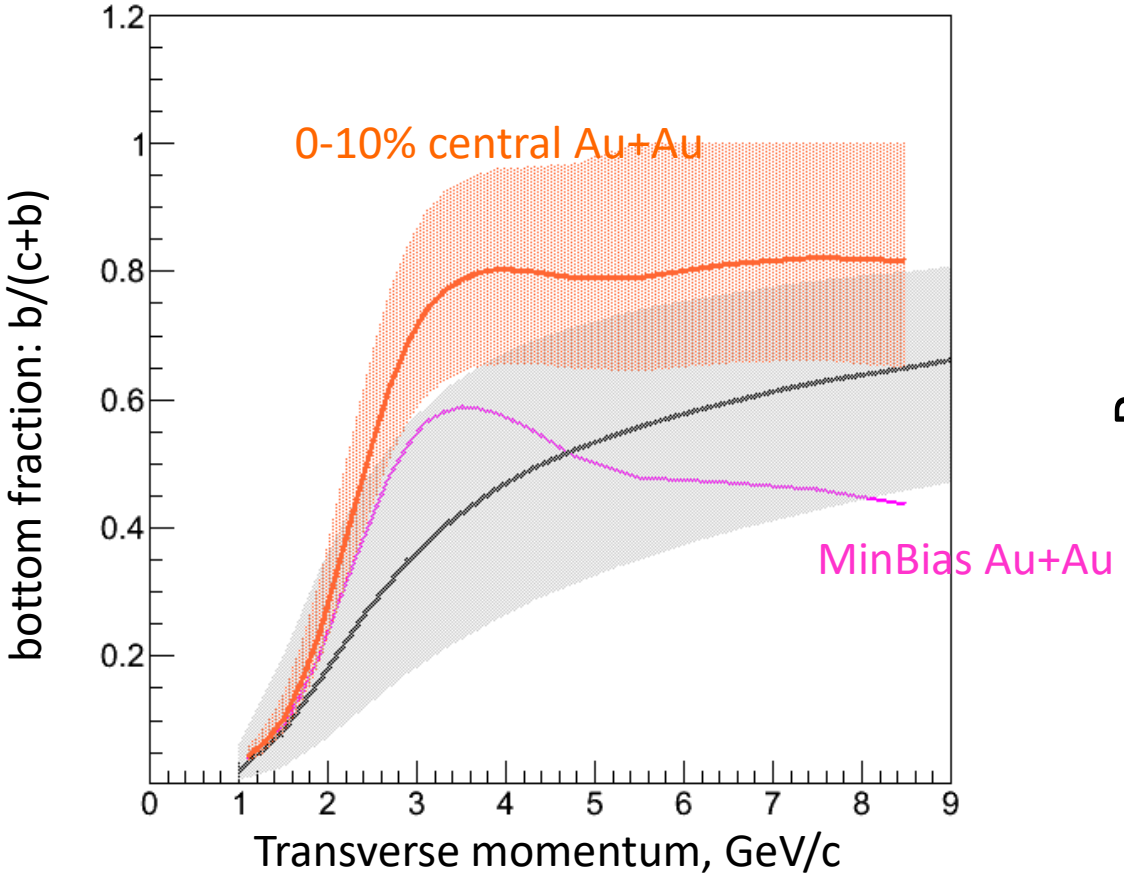
The bottom fraction in PYTHIA is not the same as the mean value for FONLL prediction, but that's OK.

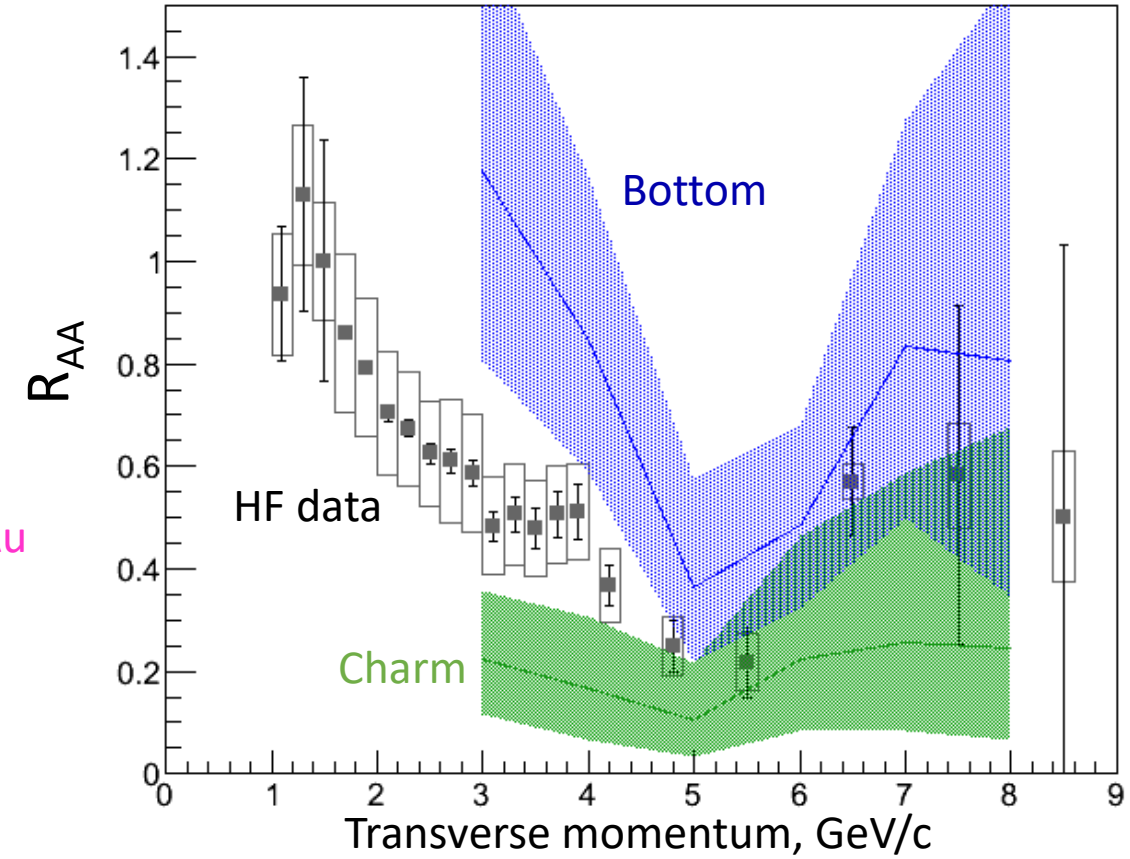
What to do with Drell-Yan cross-section?
Right now no additional scaling (and no suppression in Au+Au).

For Au+Au generate 955 × 10.0e+09 × 3.32 PYTHIA events for charm,
955 × 10.0e+09 × 3.27 PYTHIA events for bottom and apply suppression from the data (0-10% Au+Au PHENIX preliminary results from Kazuya Nagashima's talk at QM2017).

Au+Au

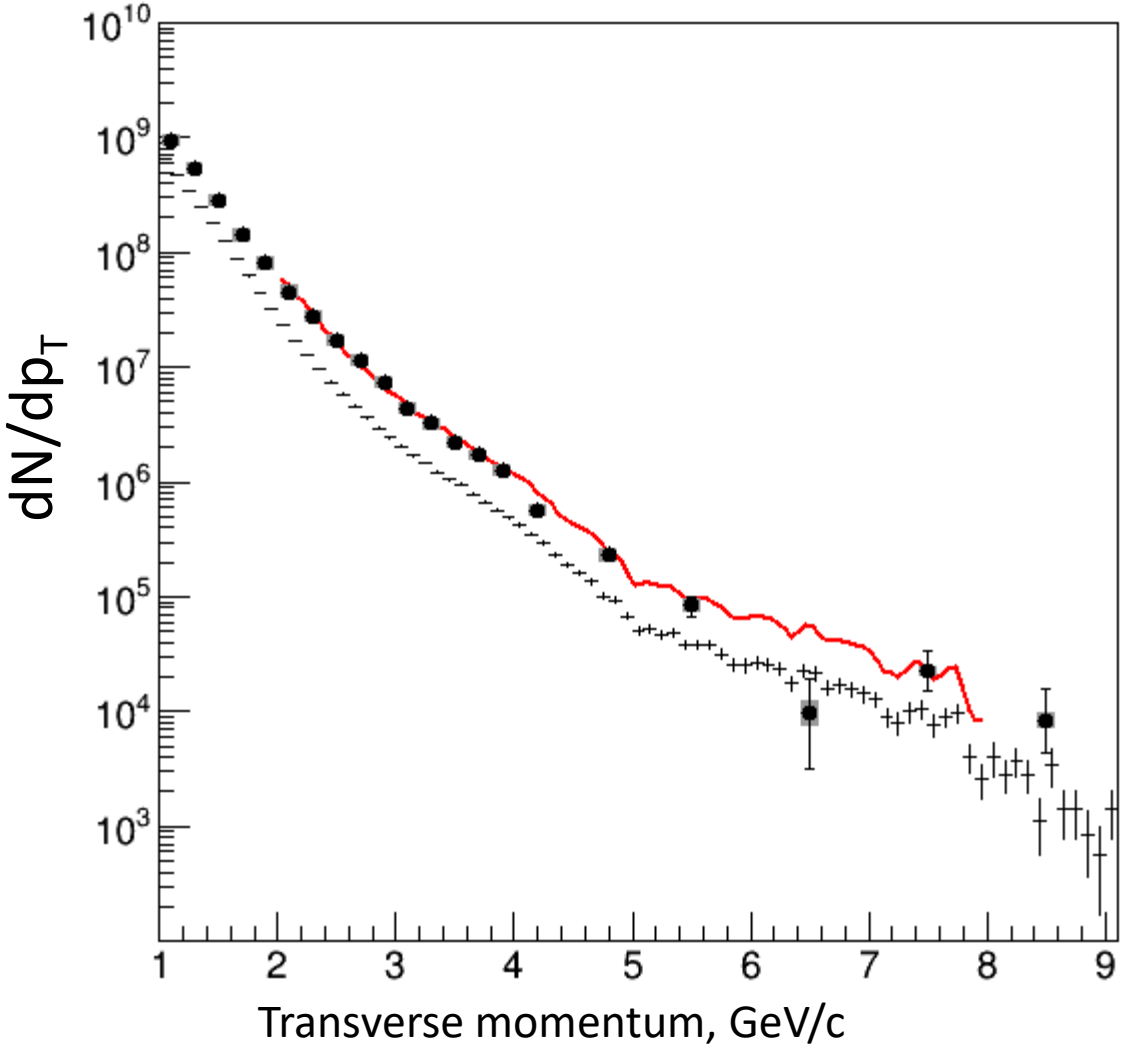
0-10% Au+Au PHENIX preliminary results from Kazuya Nagashima's talk at QM2017





Suppression is simulated by generating uniform random number from 0 to 1, and if the number is above solid green/blue curve, the electron is rejected.

Central Au+Au: Heavy Flavor single electrons



Black circles: PHENIX Au+Au data from ppg066 Scaled to 9550B Min. Bias p+p collisions, (equivalent to 10B 0-10% central Au+Au). No scaling of cross-section yet.

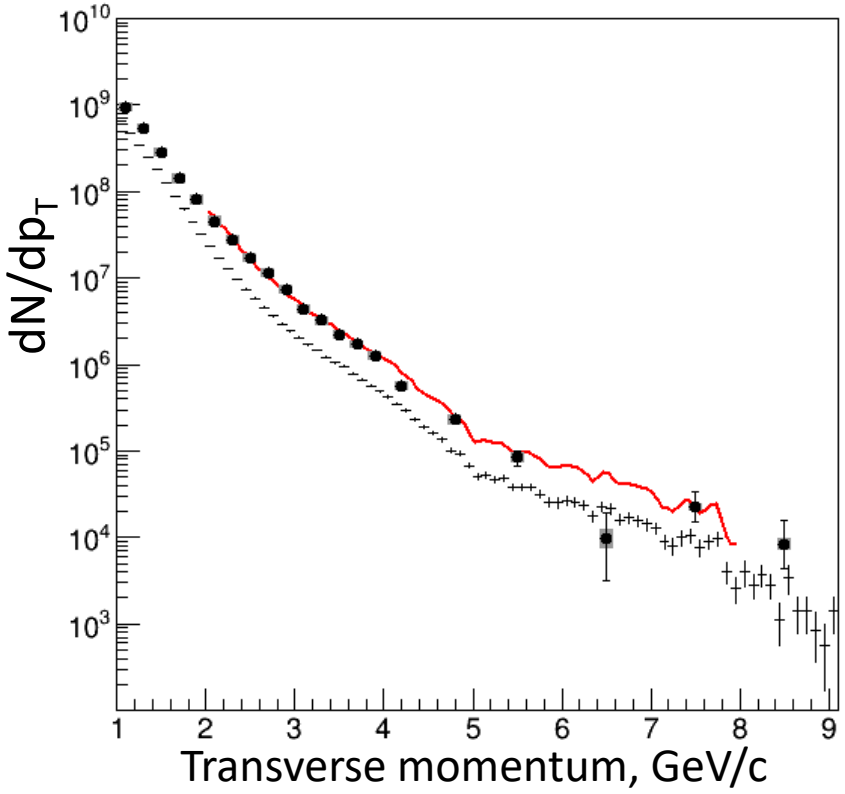
Crosses: PYTHIA corresponding to 9550B Min. Bias p+p collisions with Kazuya's suppression.

Red curve: fit of PYTHIA to the data

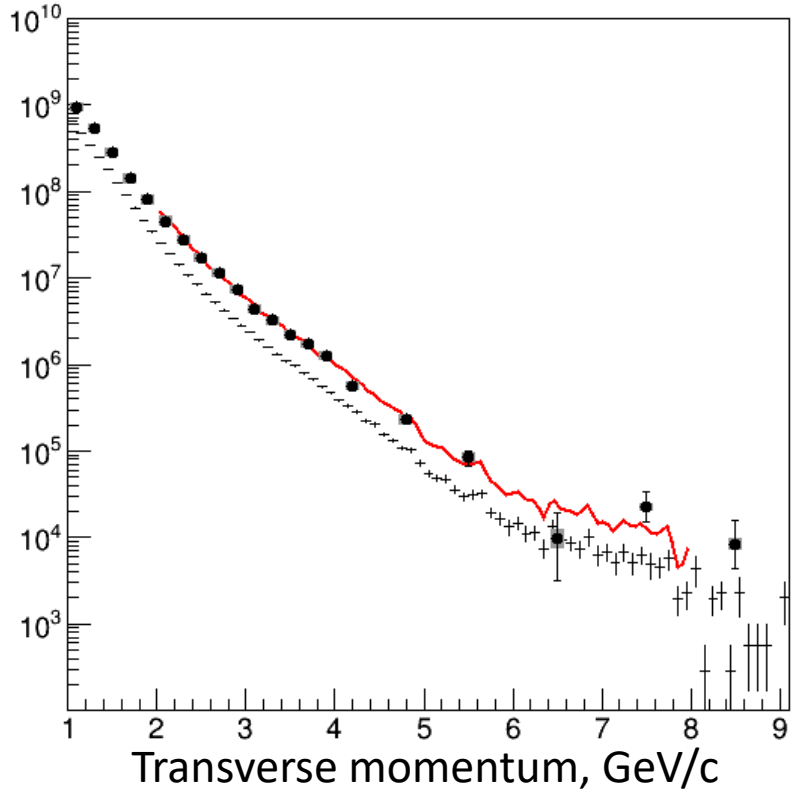
Good agreement in shape, but PYTHIA cross-section is again lower than the data.

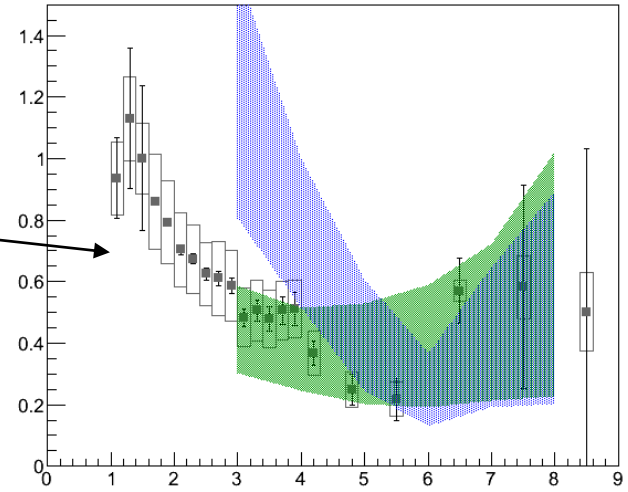
Suppression comparison

Kazuya's 0-10% central

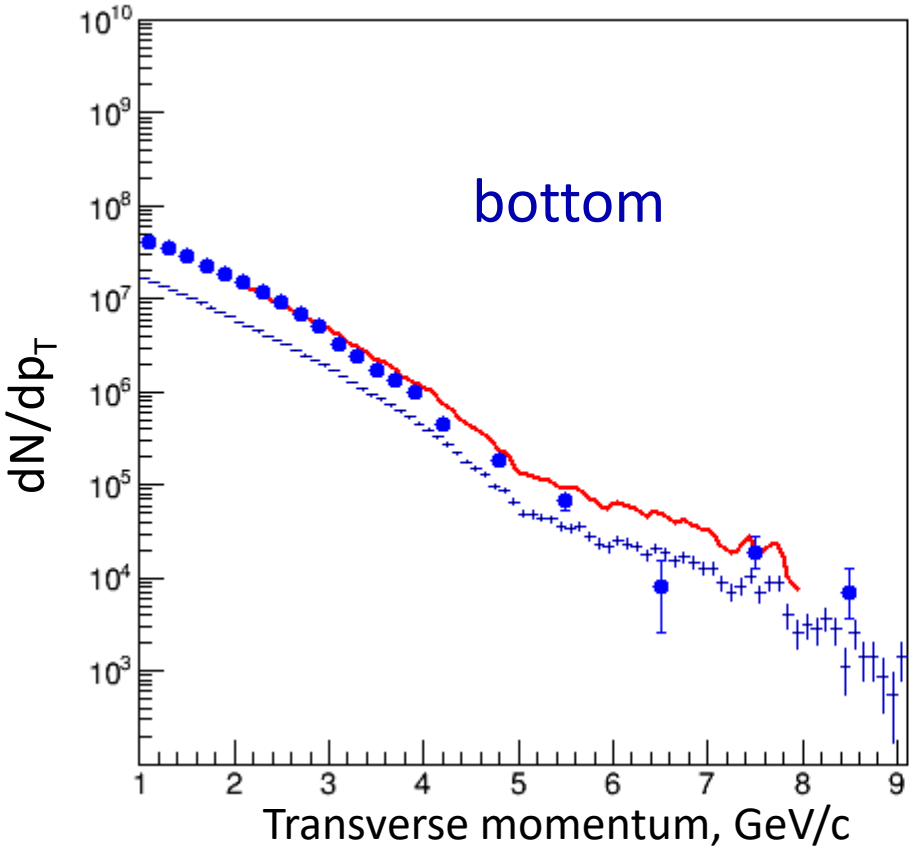


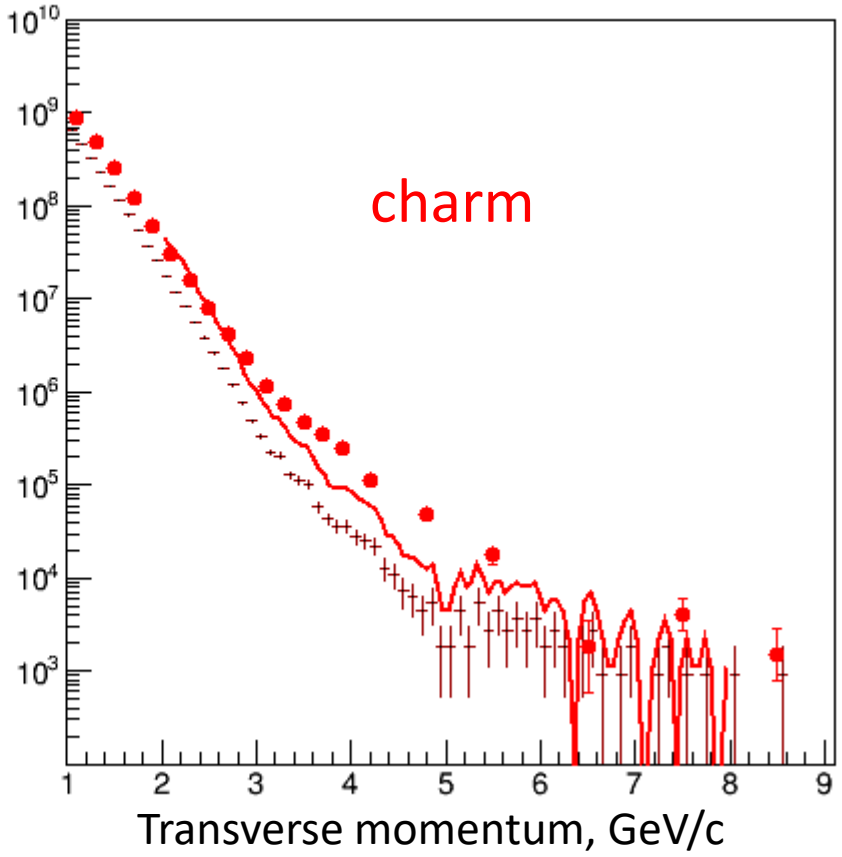
Min. Bias ppg182 suppression





Charm and bottom in AuAu (using Kazuya's results)





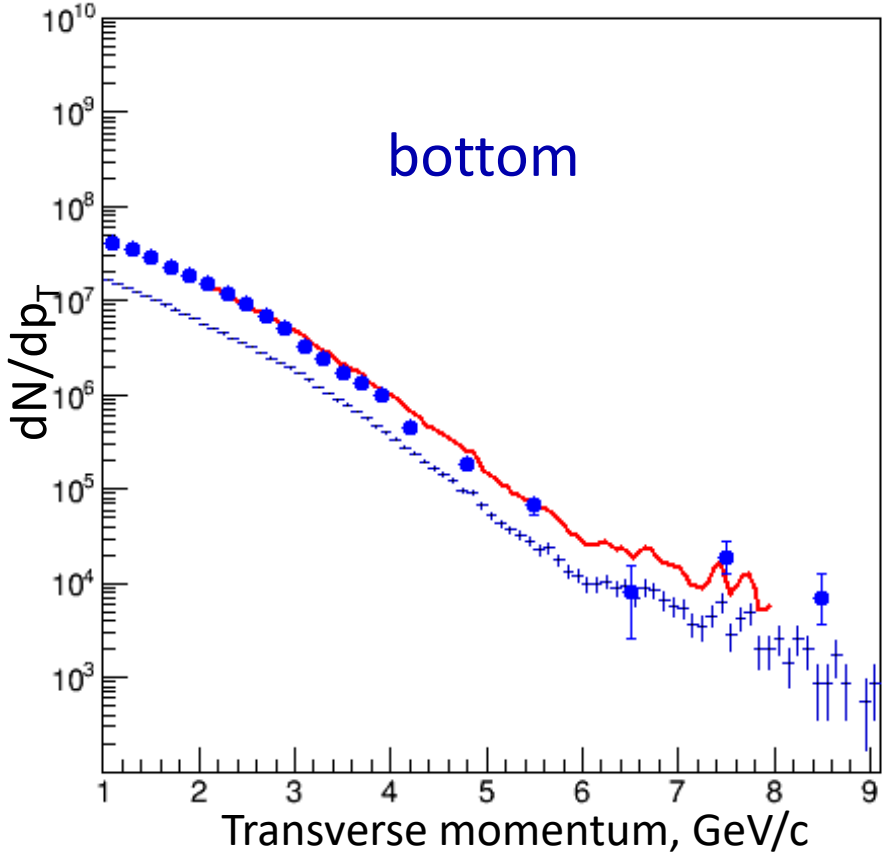
Separate data into charm and bottom using Kazuya's bottom fraction

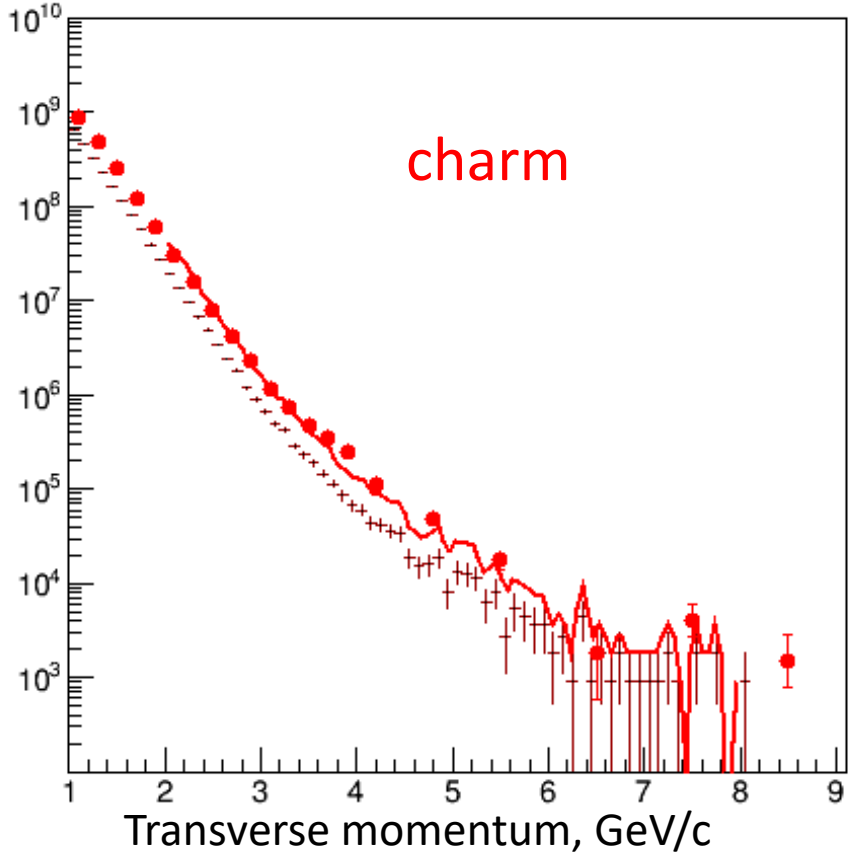
Apply Kazuya's 0-10% central suppression to PYTHIA.

Both bottom fraction and suppression in the data have very large uncertainty.

Two different way of matching PYTHIA to the data:

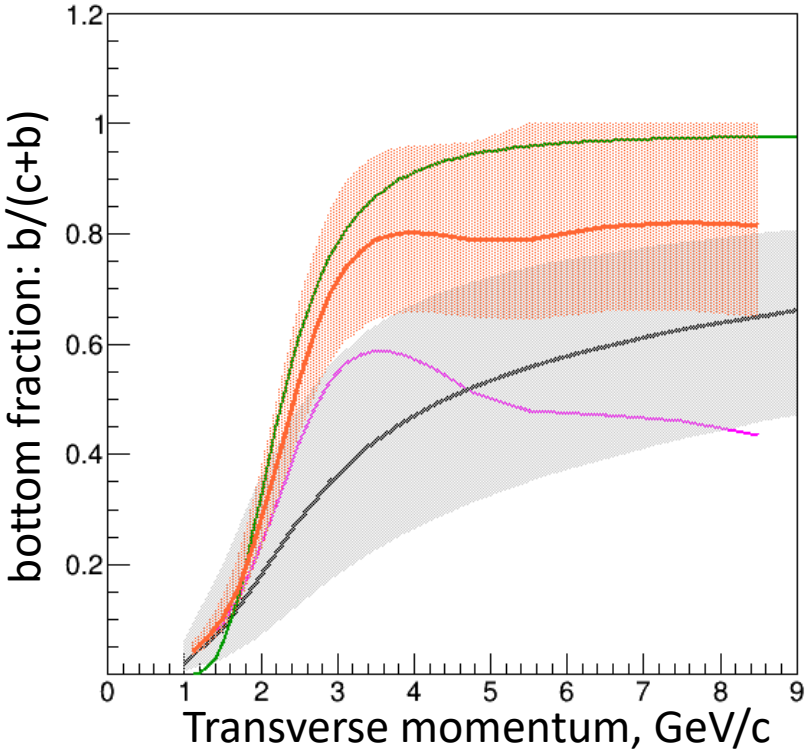
1) Using Min. Bias Au+Au suppression

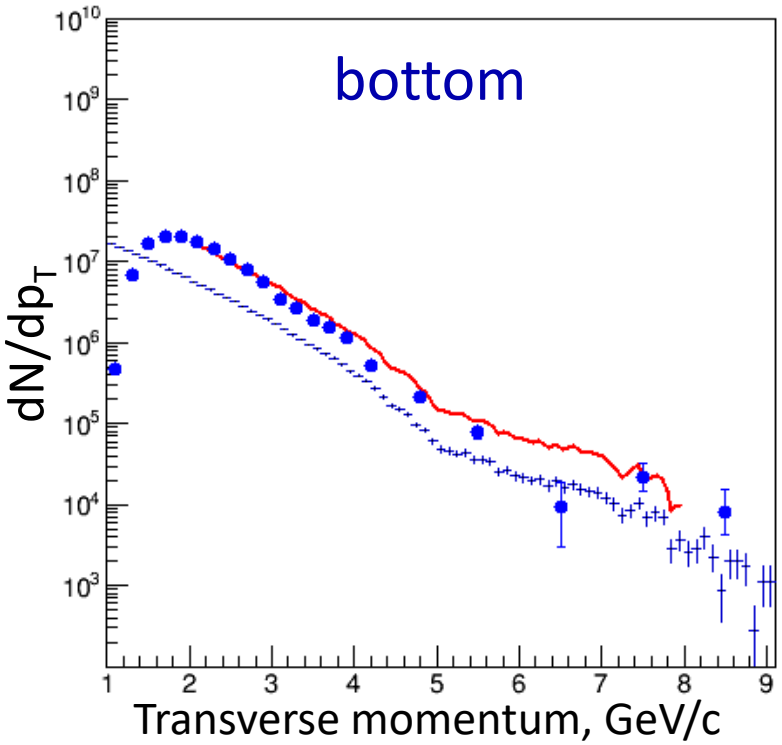


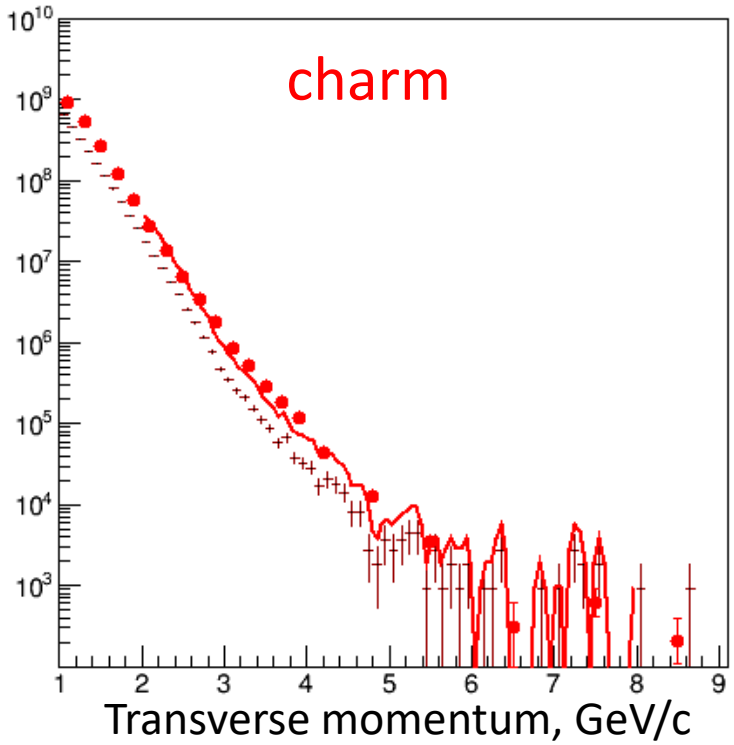


Separate data into charm and bottom using Kazuya's bottom fraction.
Apply Min. Bias suppression from ppg182 to PYTHIA.

2) Using larger bottom fraction







Apply Kazuya's 0-10% central suppression to PYTHIA.
Separate data into charm and bottom using green curve (approximately Kazuya's bottom fraction upper limit).

What suppression and bottom fraction to use?

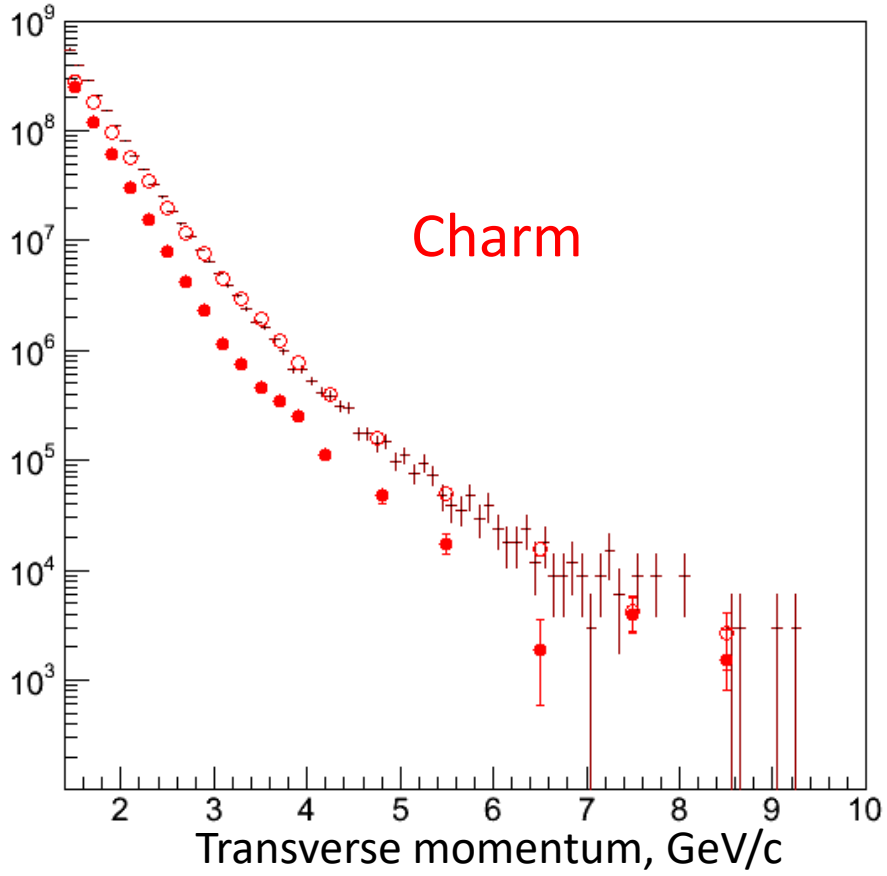
Experimentally, in Au+Au, both bottom fraction and suppression are determined with rather large uncertainty.

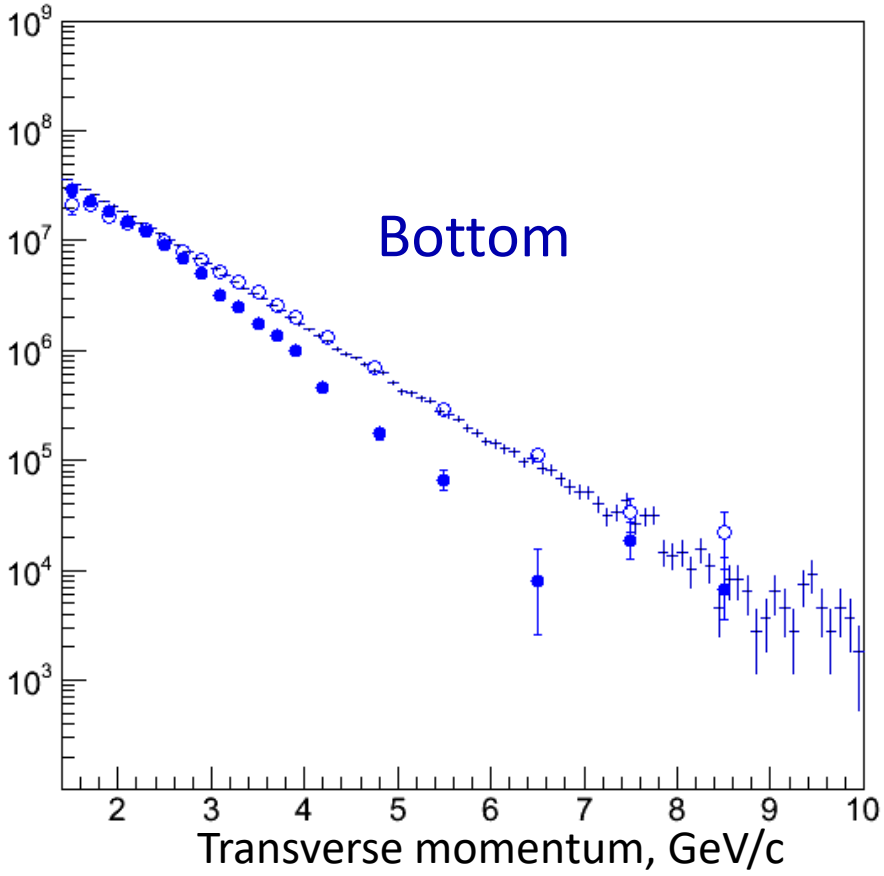
Uncertainty for R_{AA} is larger, because bottom fraction is determined directly from unfolding DCA spectra. R_{AA} is then calculated bottom fraction in Au+Au, HF R_{AA} and p+p bottom fraction.

Use measured bottom fraction, and adjust R_{AA} so that pythia matches the Au+Au data.

PYTHIA/DATA comparison

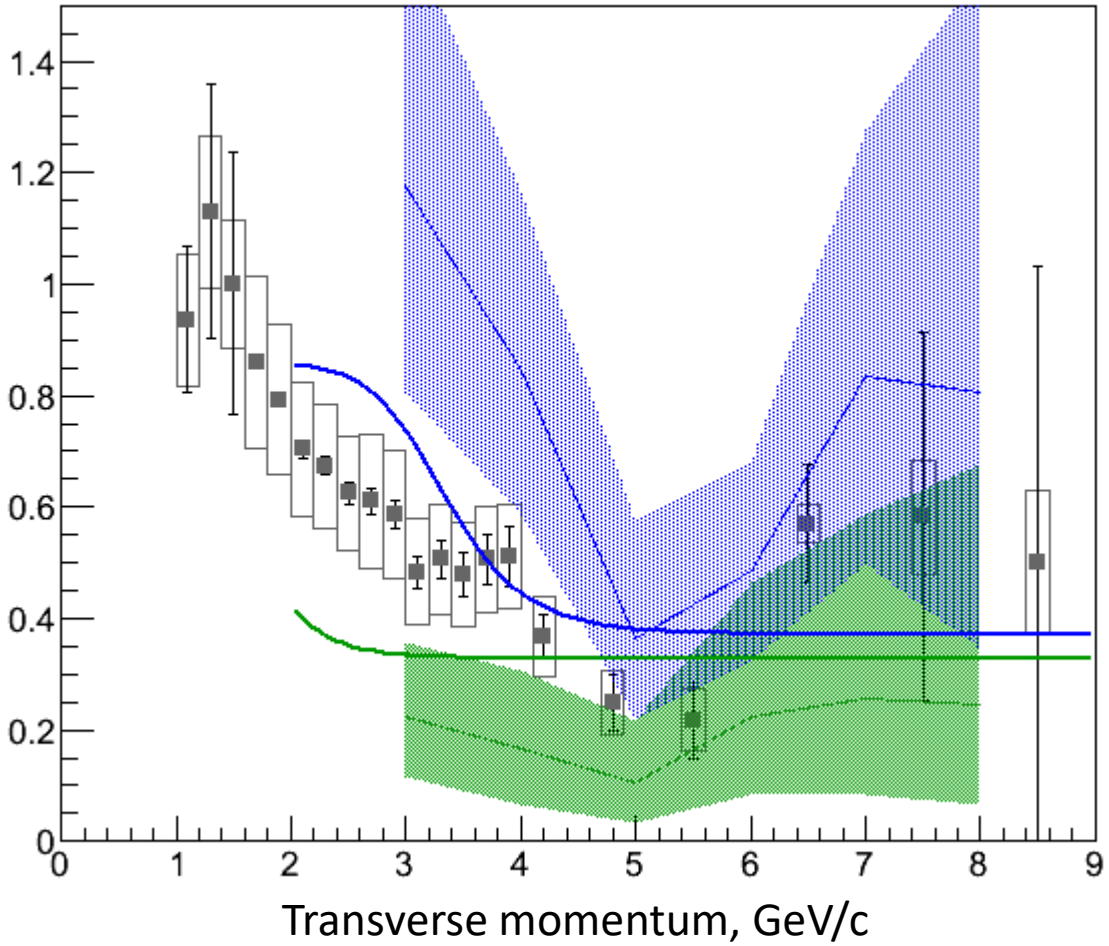
Open circles: p+p data; solid circles: Au+Au data, crosses: scaled pythia.
Divide Au+Au data by scaled PYTHIA and obtain effective R_{AA}



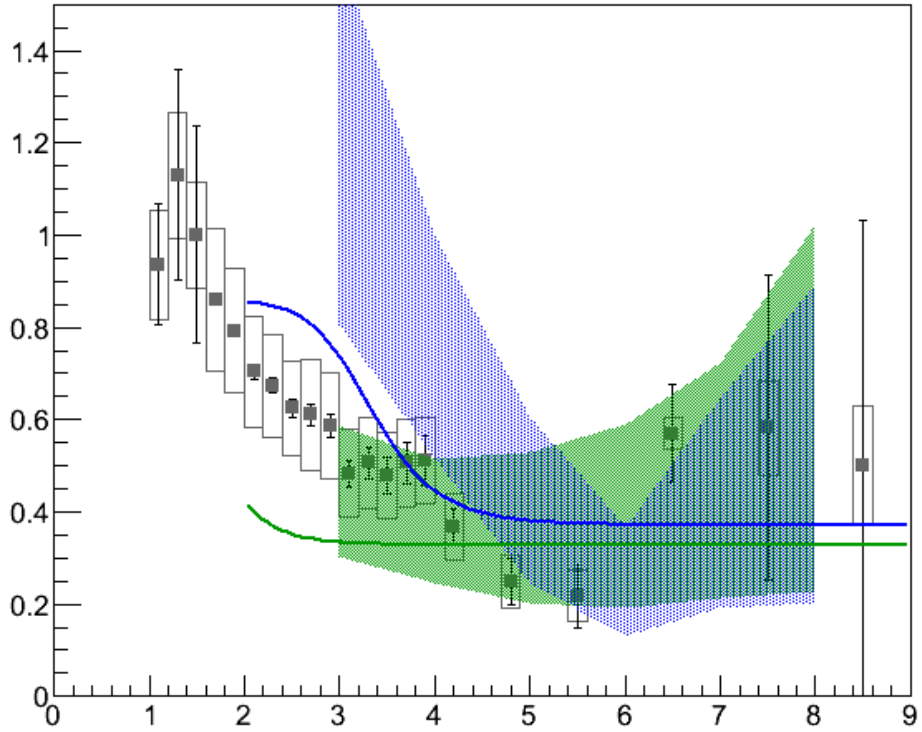


Effective R_{AA}

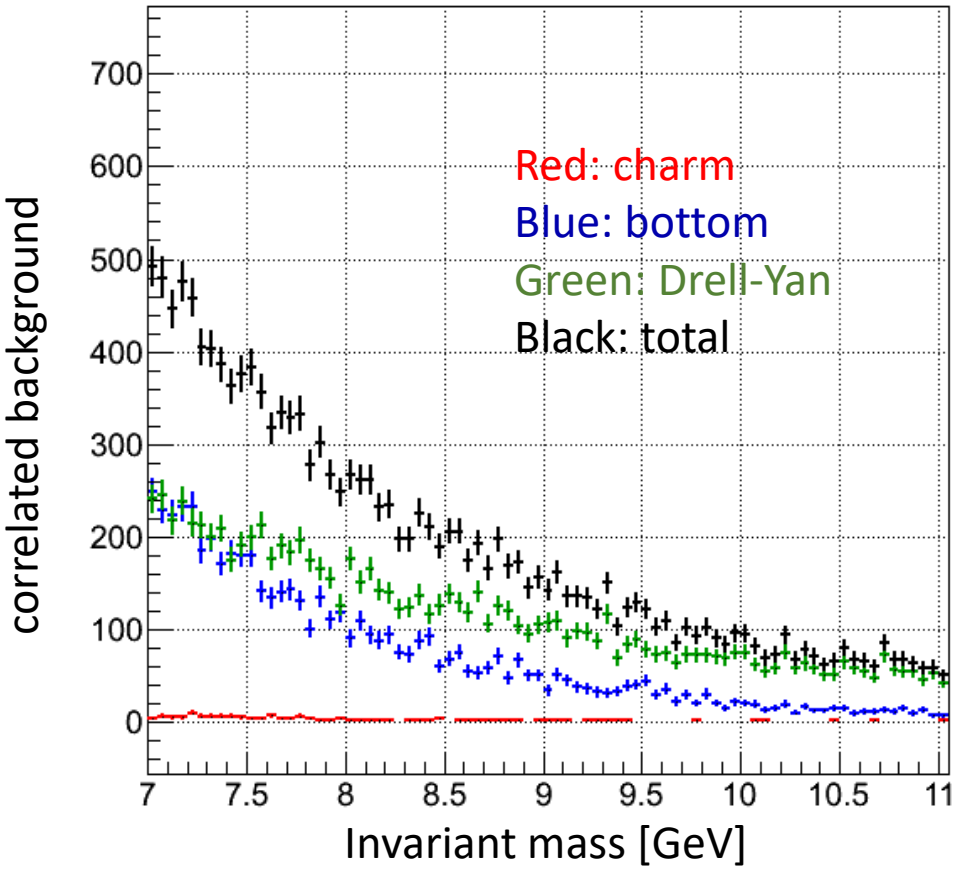
0-10% central Au+Au

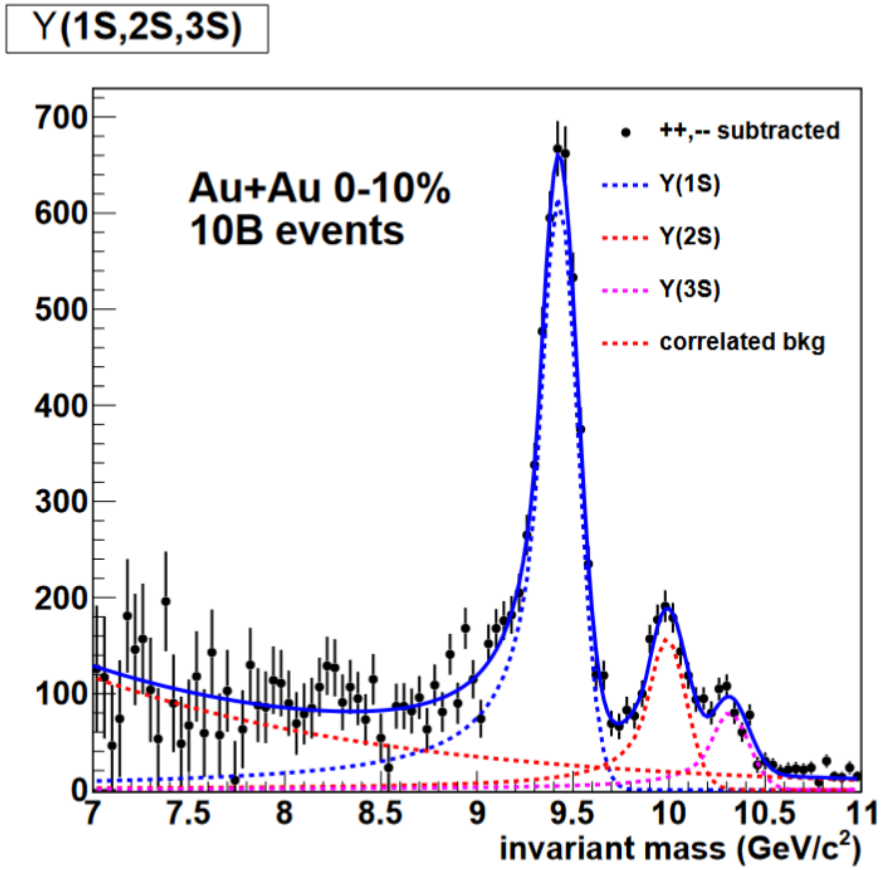


Min. Bias Au+Au



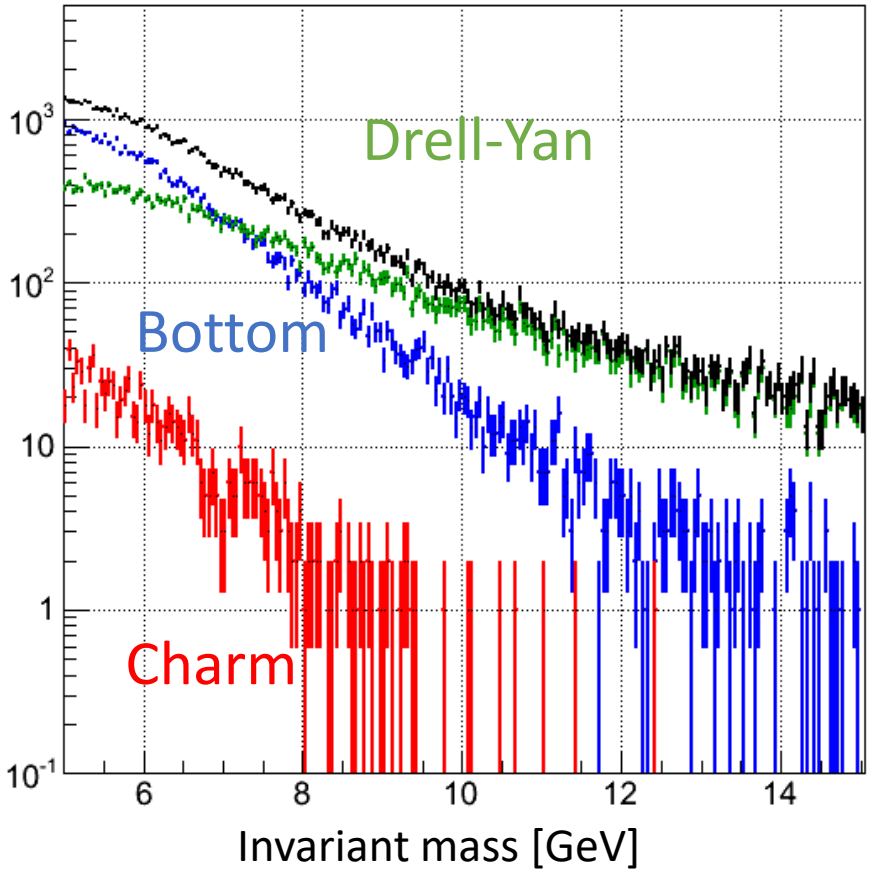
Correlated background (eID=90%)

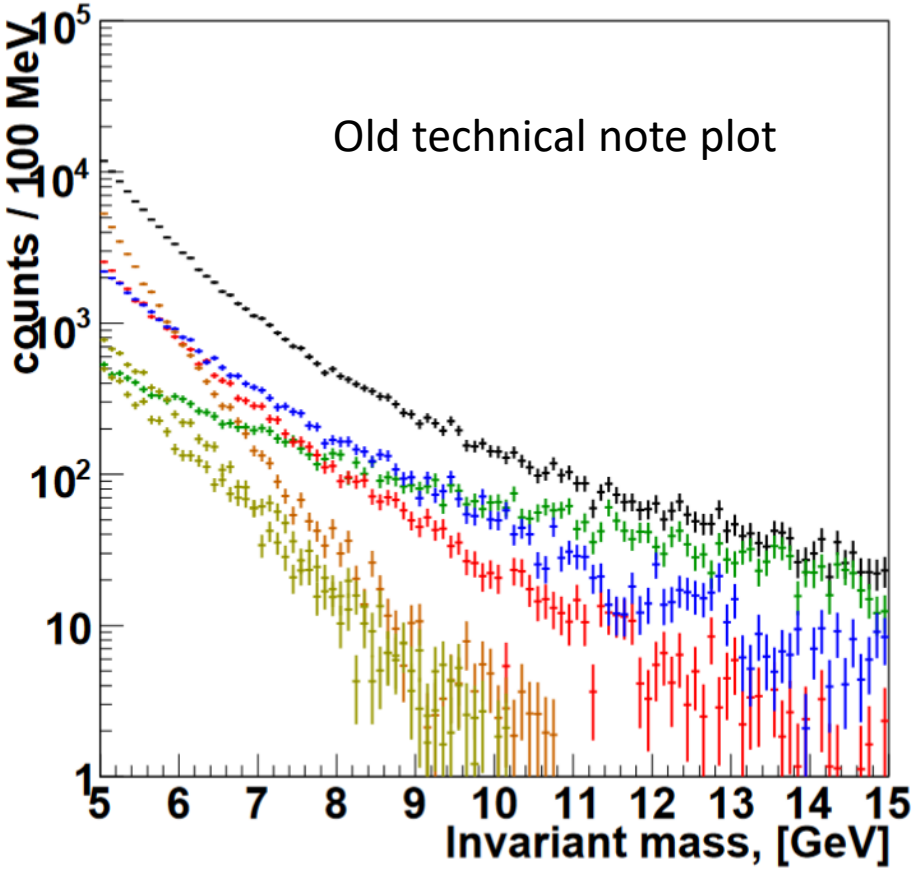




Plot on the right from sPHENIX proposal uses 70% eID efficiency, and 40MeV(?) bins.
The new plot uses 90% eID efficiency and 50 MeV bins.
New correlated background is approximately 1.5-2 times larger in 9-10 GeV range.

The background components



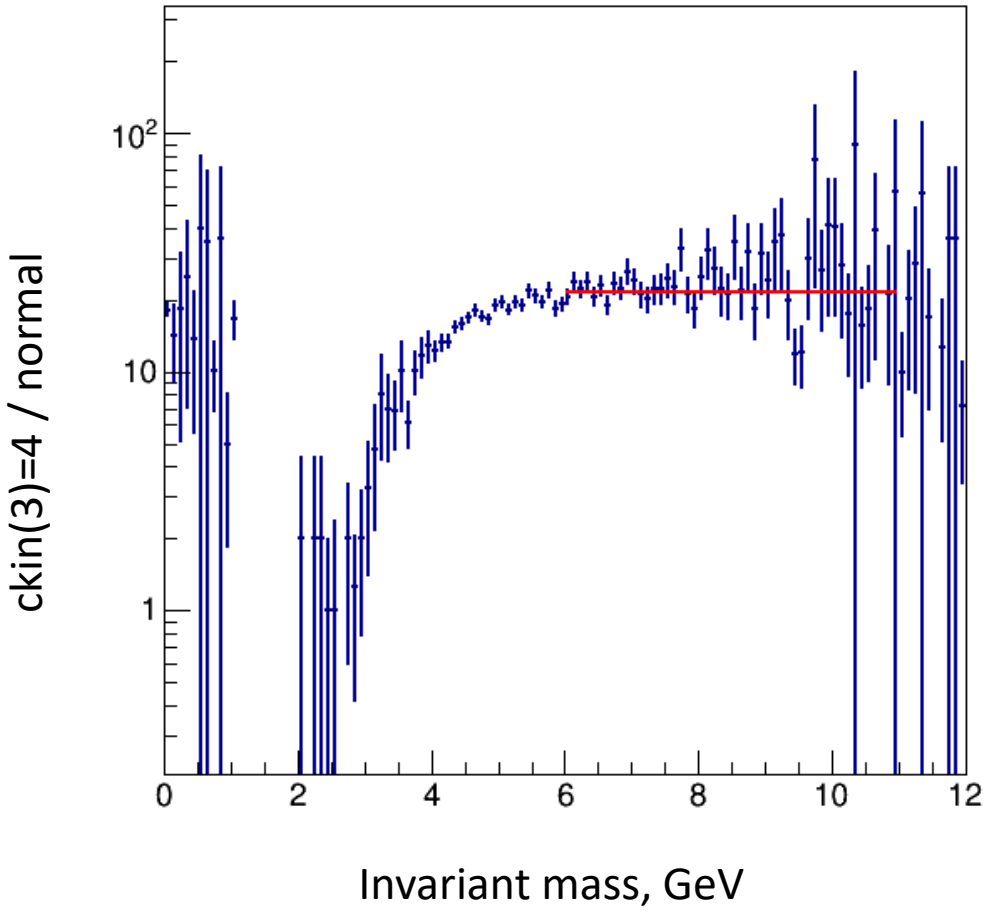


New Drell-Yan is about twice higher, bottom about the same, and charm is significantly lower.

BACKUP SLIDES

ckin(3)=4 sample normalization

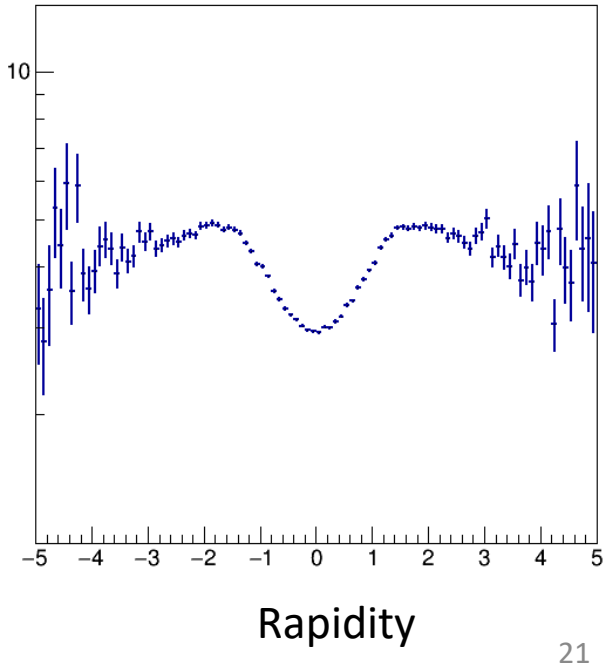
Turns out we can not use cross-section to normalize ckin(3)=4 sample.



Fit gives scaling factor 21.66 ± 0.54
Cross-section ratio gives 25.61

Acceptance for ckin(3)=4 sample is smaller, because removing low p
rapidity.

We need 1.1824 times more ckin(3)=3 events to get the same invarian
mass distribution at high mass.



Cross-sections comparison

Charm

Measured*: 544 ± 39(stat) ± 142(syst) ± 200(model) μb
PYTHIA: 187.13 μb
PYTHIA with ckin(3)=4: 0.825489 μb

Bottom

Measured**: 3.2 +1.2-1.1(stat) +1.4-1.3(sys) μb
PYTHIA: 0.734778 μb
FONLL**: 1.87 +0.99 -0.67 μb

Drell-Yan

PYTHIA: 0.118202 μb

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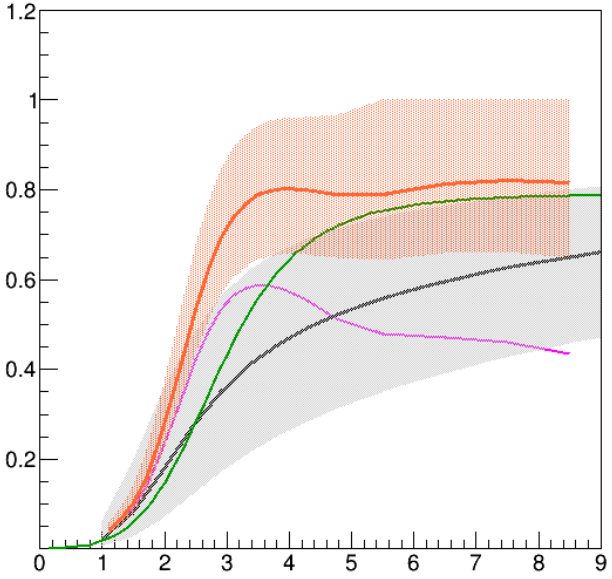
* *ppg085, arXiv:0802.0050, PLB 670, iss. 4-5, p.313 (2009)*

** *A.Adare et al., Phys.Rev.Lett., 103.082002; arXiv:0903.4851*

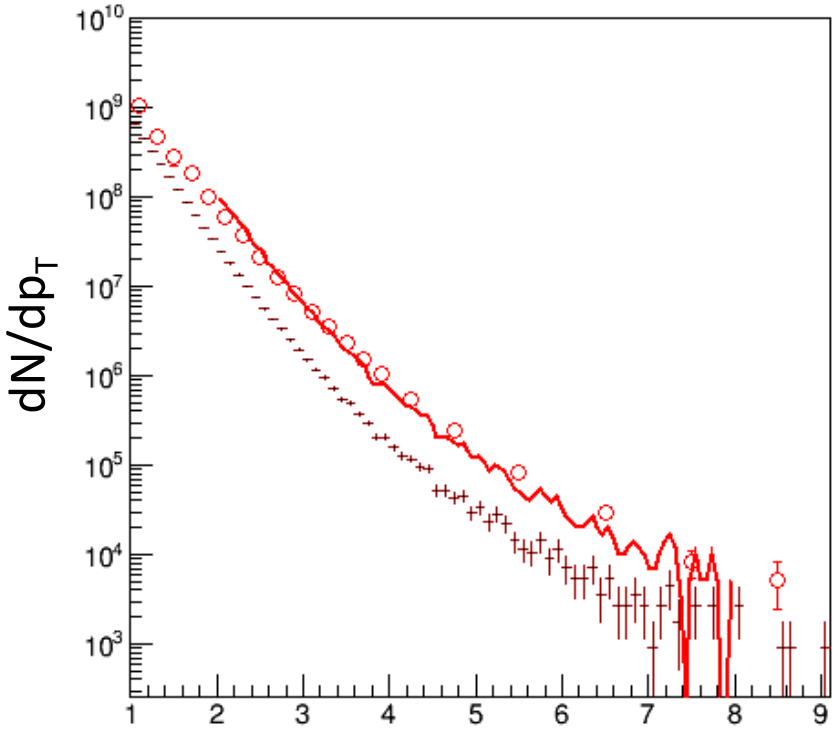
p+p charm and bottom: my own test



Transverse momentum, GeV/c

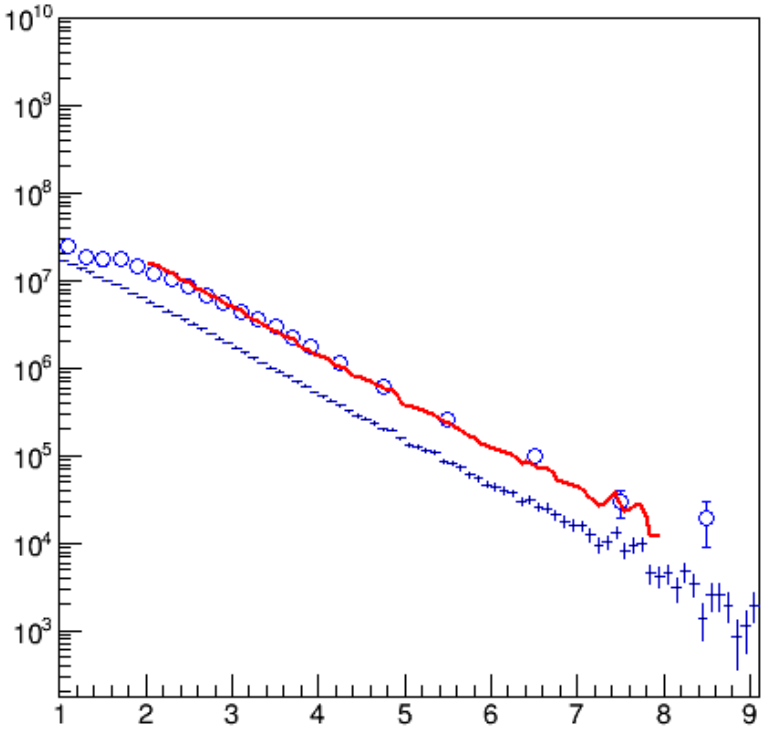
Using the green curve to separate charm and bottom

Charm



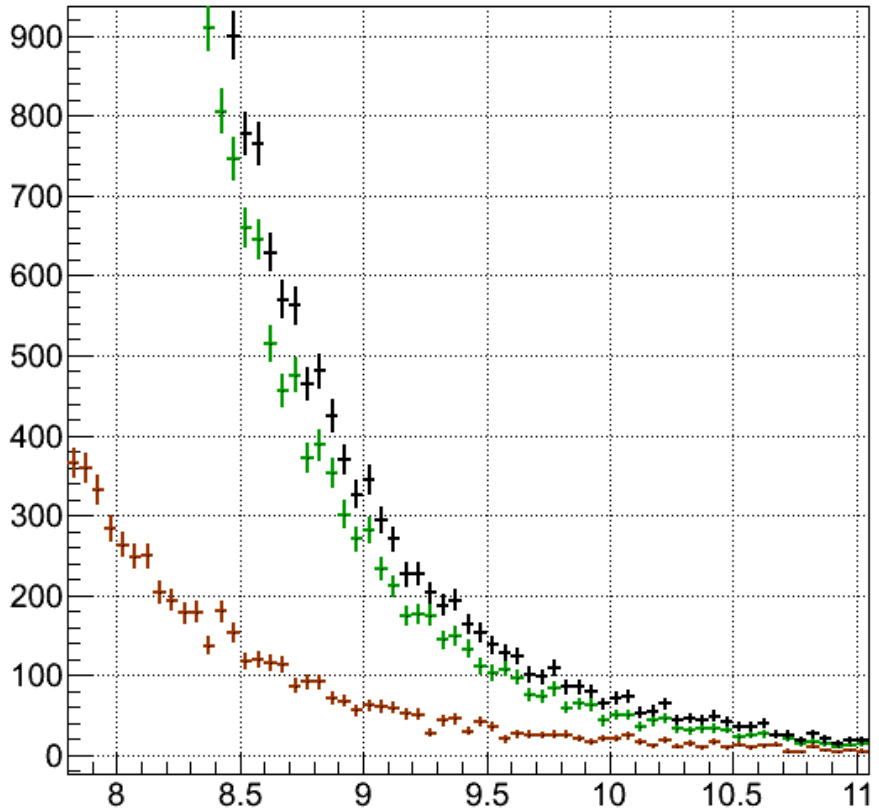
Transverse momentum, GeV/c

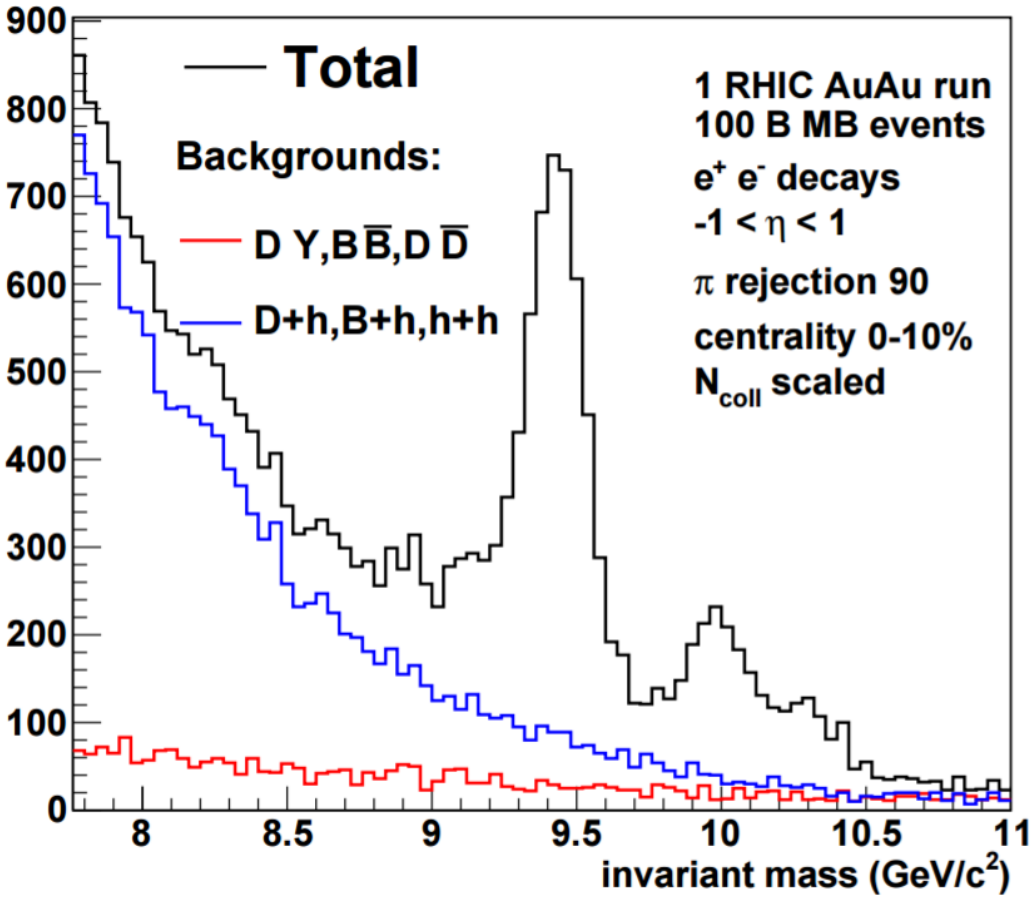
Bottom



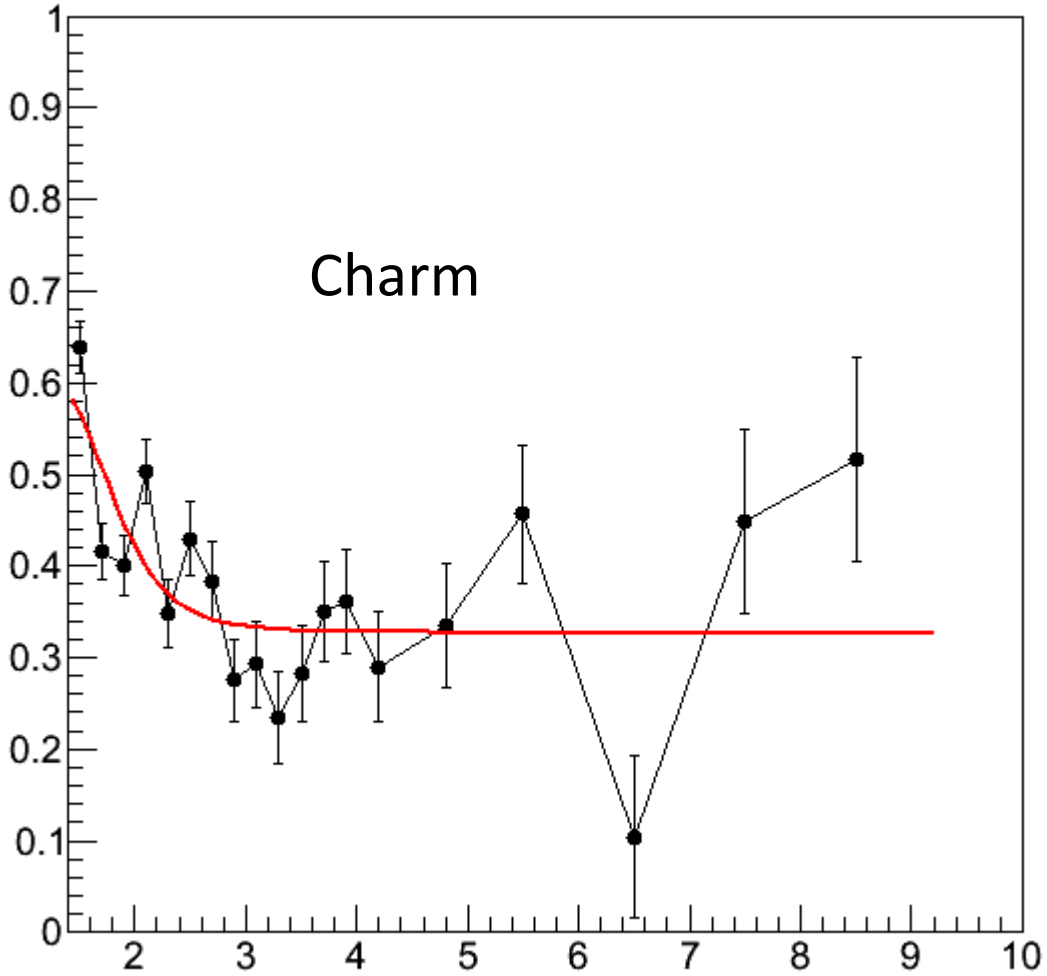
Transverse momentum, GeV/c

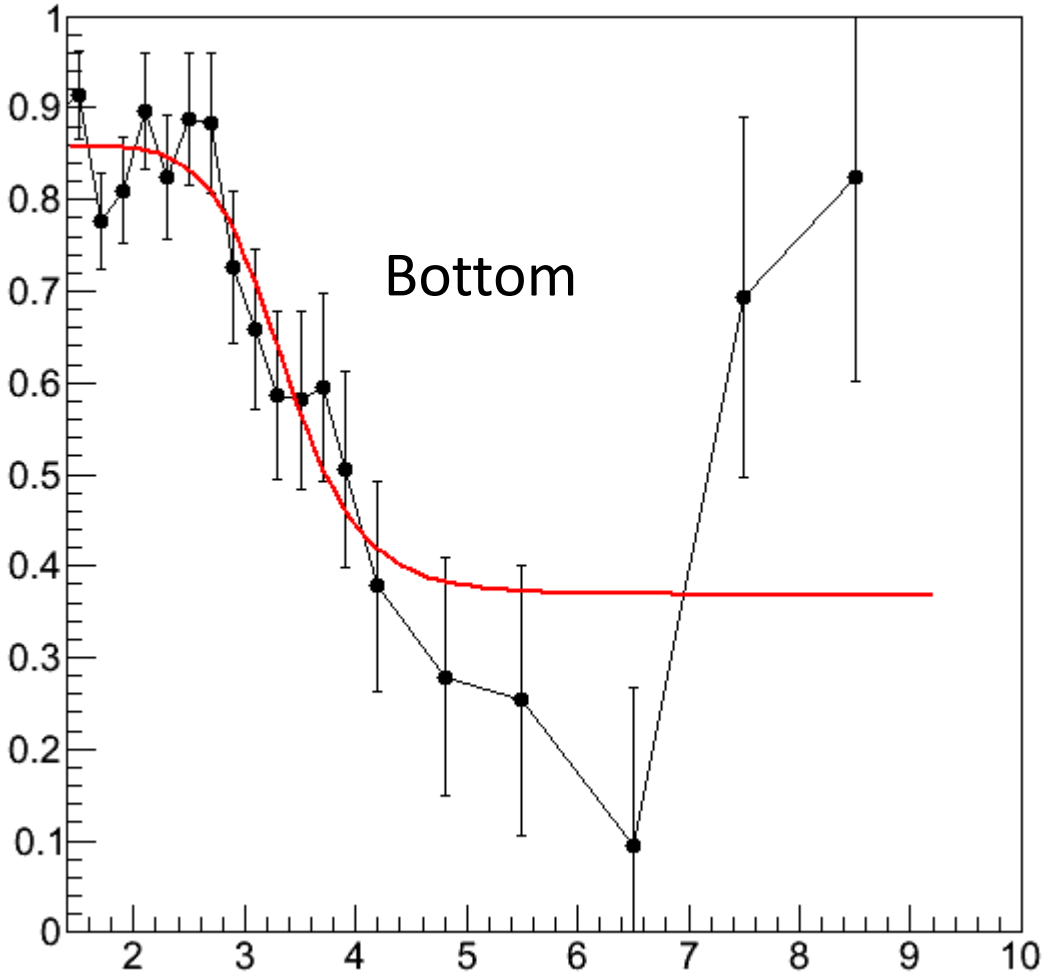
Combinatorial background





Effective R_{AA} calculation





My extrapolation of Kazuya's suppression